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AMPUTATION AND REPLACEMENT OF MARGINAL SPINES IN CTENOID PERCOID SCALES

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In the ctenoid scales of most primitive percoid fishes the spines are found only on the free edge of the scale where it is not covered by another scale. Typically each spine with its base is a separate bone (a scalelet) fixed to the fiber layer of the scale. The fiber layer forms a flexible joint between adjacent scalelets. Cycloid scales in some genera, for example *Rypticus* and *Grammistes,* have homologous scalelets that lack spines; in other genera, for example *Siniperca*, the posterior fields lack scalelets that are homologous with the spines of ctenoid scales.

Posterior growth in the scales that have spines is by increments of single scalelets. Except for rare and inconsistent specimens or species, new scalelets do not form radially to another unless at least the tip of the spine has been lost or amputated. When two spines outgrow, the one between them (the shorter and older spine) tends to lie flatter than it did and the tip is amputated by osteoclasis. Nearly always, solution pits can be seen on the end of the stump. Then a new scalelet will be laid down distal to the stump. Eventually the new one will grow until it extends beyond its neighbors and they in turn will be amputated and replaced.

The fully grown scalelets with their spines stand erect or nearly so and hold up the connecting fiber layer and the overlying soft tissues of the epidermis and scale pocket. This forms a ridge usually in the arc of a circle that projects from the side of the fish. Except at the free edge, the posterior fields of such scales are covered with the amputated stumps of scalelets that once bore the spines that made the scale ctenoid.

The figure shows all the steps in the life cycle of one of these marginal spines except for some intermediate sizes in the growth of the scalelet. It shows part of the free margin of the posterior field of a scale, 2.79 mm. long, from the flank of a pike-perch, *Stizostedion canadense* (Smith), SU–5673. It is unusual in that it shows the amputated tip of a scalelet still in position. Usually such a tip is lost soon after it is cut off. Most of the scales from this fish show 1 or 2 scalelets in this condition. It is the only fish I have yet encountered that showed any tips of amputated spines and the beginning of the new scalelets beneath them.

The scalelet that has just been amputated is the marginal one that does not reach as far back as the others. The original length of this scalelet was 0.165 mm. The tip is 0.059 mm. long. The gap from which the bone was removed is 0.013 mm. wide. The primary ossification of the forming scalelet is wider than the old tip and lies beneath it. The new ossification measures 0.027 mm. in the anteroposterior diameter and is 0.045 mm. wide. Eventually the new scalelet will extend beyond the two beside it and they in their turn will be amputated and replaced.

The specimen was cleaned of as much adhering soft tissue as possible, stained with Alizarin Red S., and mounted in air under a cover slip secured with a few drops of polyvinl chloride glue. The mount is so made that it dries under pressure and the free edge of the scale is held down. The gaps between the scalelets shrink on drying and are now narrower than they were in life. In spite of the cleaning, a layer or two of cells lies over the bony tissues in most of the figure.

Williamson (1851) was the first to notice that the posterior field of perch, *Perca,* scales were made up of the bases of spines that were broken off. Baudelot (1873) saw that the perfect spines were only at the margins and that all spines not marginal were broken (brisée). He concluded, as had Williamson, that the spines were formed at the free edge. Neither one is able to explain how the scalelets became broken and Bauelot says that more observations are needed. Hase (1911) studied perch, young of the year, and reached the mistaken conclusion that the posterior scalelets were formed near the nucleus and pushed out toward the margin. At the margin they then grew their spines. There was no clear explanation of what happened until I completed my doctoral research (McCully, 1961).

From my examination of this and material from the Serranidae I conclude:

1. That the small size of the amputation gap means that only a few cells can be excreting the osteoclastic material.

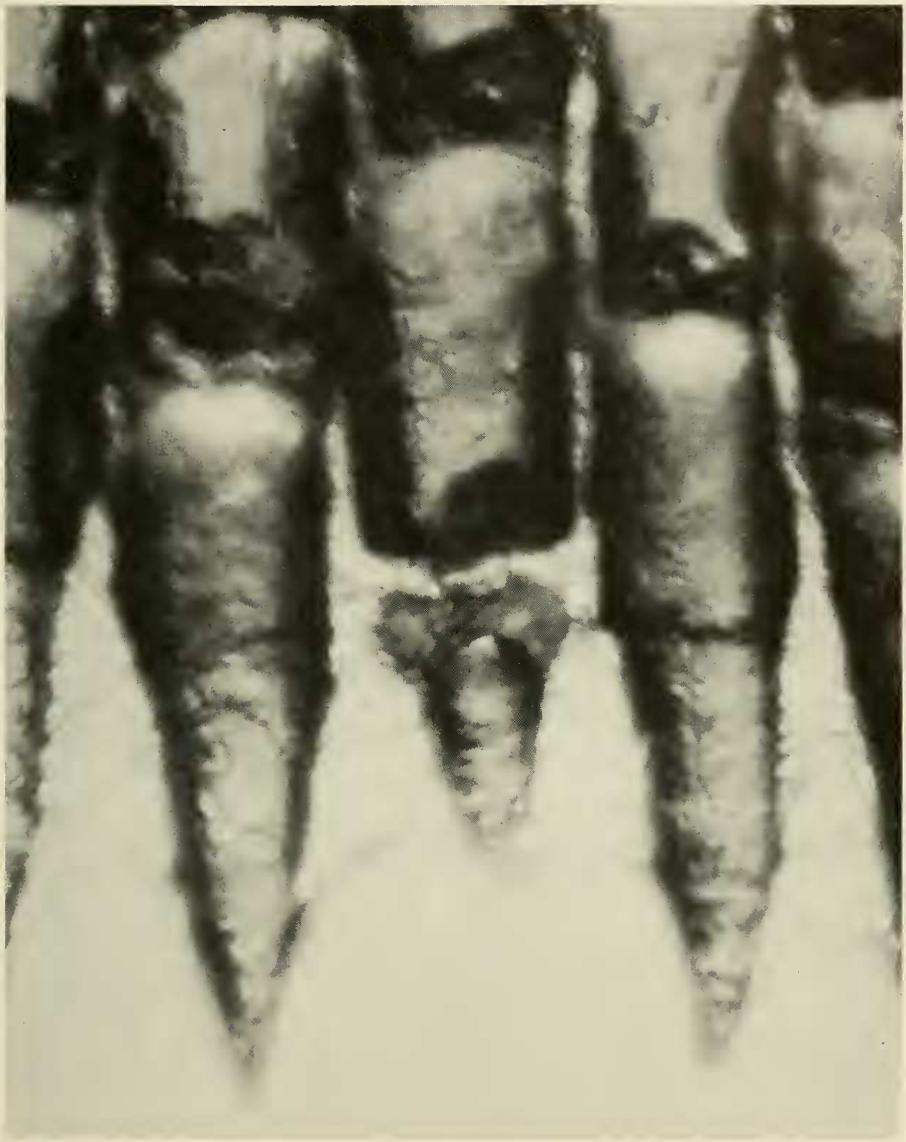

Figure 1. Posterior margin of scale from the flank of a pike-perch, *Stizostedion canadense.* (See text for explanation.)

2. Nearby cells must be protecting the bone that is not attacked.
3. The material removed from the bone may be redeposited nearby.
4. There is a regulating mechanism that can differentiate the excretory activities of a few selected cells from their neighbors. Another regulatory

change stops the unusual secretion and returns the cells, presumably, to their former state.

5. It is possible that migratory cells are the source of osteoclastic excretion.

6. There is, in a very small area, exposed to external observation and manipulation the whole of the sequence of bone growth and absorption. This type of scale offers a convenient way to test the action of drugs in an intact animal on any aspect of the physiological processes of bone growth and absorption except for those peculiar to the replacement of cartilage.

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